Closure Welding Design and Justification for Canister S00645 (Bent Flange)

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DOE Contract No. **DE-AC09-96SR18500**

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WSRC-TR-98-00414

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November 1998

DOCUMENT: WSRC-TR-98-00414

TITLE: CLOSURE WELDING DESIGN AND JUSTIFICATION FOR CANISTER S00645 (BENT FLANGE) (U)

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INTRODUCTION

On October 1, 1997, Canister S00645 nozzle was damaged during process preparation for closure welding at the Weld Test Cell (WTC), Defense Waste Processing Facility (DWPF)[1]. The sustained damage, distortion of the nozzle flange and bore, is such that routine closure welding using the DWPF Welder (resistance upset welding (UW) process) is not feasible. As part of an overall disposition effort, the Materials Technology Section (MTS-SRTC) was requested to evaluate the Gas Tungsten Arc Welding (GTAW) process as an alternate to UW welding for closure of Canister S00645[2].

This report provides the design basis and justification for a closure welding technique using the manual GTAW process. Other aspects affecting closure of Canister S00645, e.g., shielding, facility and administrative requirements, etc., are addressed elsewhere[3].

BACKGROUND

The routine method for closure of DWPF radioactive waste-filled canisters is to weld a 1/2 inch thick by 5 inch diameter 304L stainless steel plug into the nozzle bore using the UW process[4]. The UW welded closure is designed to produce leaktightness and mechanical properties that meet requirements of the Waste Acceptance Product Specifications (WAPS). In addition, the weld is designed to meet or exceed specified minimum strength levels of the canister. Parameter development for the UW closure weld was carried out in a statistically based, parametric test program referred to as the Parametric Study[5]. The qualified parameter ranges were shown to produce acceptable welds and when verified through real-time data acquisition, form the basis for acceptance of production welded canisters. Conventional volumetric examination (i.e., radiographic and ultrasonic test methods) is not performed on the UW (solid-state weld) closure because it has not been shown to accurately characterize bond quality on a consistent basis[6]. Acceptability of GTAW welds (fusion welds); however, can be and are routinely based on post-weld examination, eliminating the need for "up-front" qualification (i.e., parametric studies). The proposed closure weld for Canister S00645 will be accepted on the basis of post-weld volumetric and leaktightness testing.

GTAW welding was considered a strong candidate for closure of Canister S00645 because of the success West Valley Demonstration Project (WVDP) has had with this process. WVDP developed and qualified their closure in accordance with WAPS criteria and has successfully closure-welded nearly 250 radioactive, waste-filled canisters (WVDP canisters are similar in design to those at DWPF).

The following outlines the design and basis for a GTAW technique to be used for closure-welding Canister S00645:

DESIGN AND JUSTIFICATION FOR THE S00645 GTAW CLOSURE

The GTAW closure of Canister S00645 will consist of manually welding a 1/2-inch thick by nearly 5-inch diameter 304L stainless steel plug into the nozzle bore. As noted above, the nozzle is damaged (slightly eccentric bore and bent flange)[7]. This, however, should not affect the ability to successfully deposit the weld and complete the closure. The joint design is a single bevel, full-penetration groove and meets ASME Section VIII criteria[8]. A sketch of the GTAW and standard DWPF UW weld joints is shown in Figure 1.

The UW closure is designed to produce a weld throat of at least 0.335 inches (0.375" - 0.425" typical) matching the minimum specified thickness of the canister wall[9]. Joint design for the GTAW closure will create a weld throat length of 0.500 inches. Welding Procedure Specification (WPS) and personnel performing the welding will be qualified in accordance with ASME Section IX[10]. ASME qualification will confirm that mechanical properties of the GTAW weld will match or exceed those specified for the canister materials and that the welder has sufficient skill to deposit sound weld metal.

Soundness of the S00645 closure will be verified by Ultrasonic Test (UT) examination of the completed weld. UT will be performed and accepted in accordance with ASME Section VIII criteria.

WAPS requirements (addressing leaktightness of the final closure)[11], will be verified by leak testing the completed S00645 closure using the solution film test method. Testing will follow ASTM E 515, Standard Test Method for Leaks Using Bubble Emission Techniques[12]. This method is sensitive to the limit of at least 1×10^{-4} atm-cc/sec, which meets the WAPS leaktightness criterion for final closure.

In addition to specified leaktightness requirements for final closure, the WAPS requires verification of leaktight integrity subsequent to postulated impact conditions. Drop testing of canisters, closure-welded with the UW design, was conducted and met specified criteria[13]. The GTAW closure design matches the overall configuration and exterior envelope dimensions of the UW closure. Because the configuration and mechanical properties of the GTAW design match those of the UW, post-impact leaktightness is expected to be equivalent as well.

The following summarizes key elements that support acceptability of the GTAW closure design from both a technical and a code compliance (WAPS) standpoint:

- Design and qualification of the closure weld in accordance with ASME Sections VIII and IX (weld properties meet/exceed levels specified for the canister materials);
- maintaining weld-joint design and overall configuration to match that of the UW closure (maintains mechanical equivalency - including impact properties);
- post-weld nondestructive examination (NDE) in accordance with ASME Section VIII to verify weld soundness, and
- post-weld leak testing in accordance with ASTM E-515 to verify WAPS leaktightness criteria.

Successful closure of Canister S00645 using the GTAW technique, as described herein, should produce a closure that is functionally equivalent to one made by the DWPF Welder (UW). Because of functionally equivalency, no unique restriction or limitation, regarding the subsequent storage and handling of Canister S00645 should be necessary. Prior to performing the actual closure, mockup testing will be conducted to confirm weld properties and feasibility of the overall technique.

DEMONSTRATION AND MOCKUP TESTING OF THE GTAW CLOSURE TECHNIQUE

A mockup of Canister S00645 nozzle will be prepared for welding. Weld-joint design, fit-up and other pertinent elements unique to the S00645 nozzle will be duplicated. The mockup will be welded under conditions representative of the actual work, i.e., shielding, protective clothing, facility arrangements, etc., and tested as follows:

- Visual Inspection - demonstrate weld soundness and root penetration
- Ultrasonic Test (UT) - demonstrate weld soundness (volumetric)
- Leak test (Solution Film and Helium Leak test methods) - demonstrate leaktight integrity
- Burst test - demonstrate mechanical strength
- Fractography of the fracture surface - assess failure mode (brittle or ductile)

RECOMMENDATION

DWPF should proceed with closure of Canister S00645 as outlined above.

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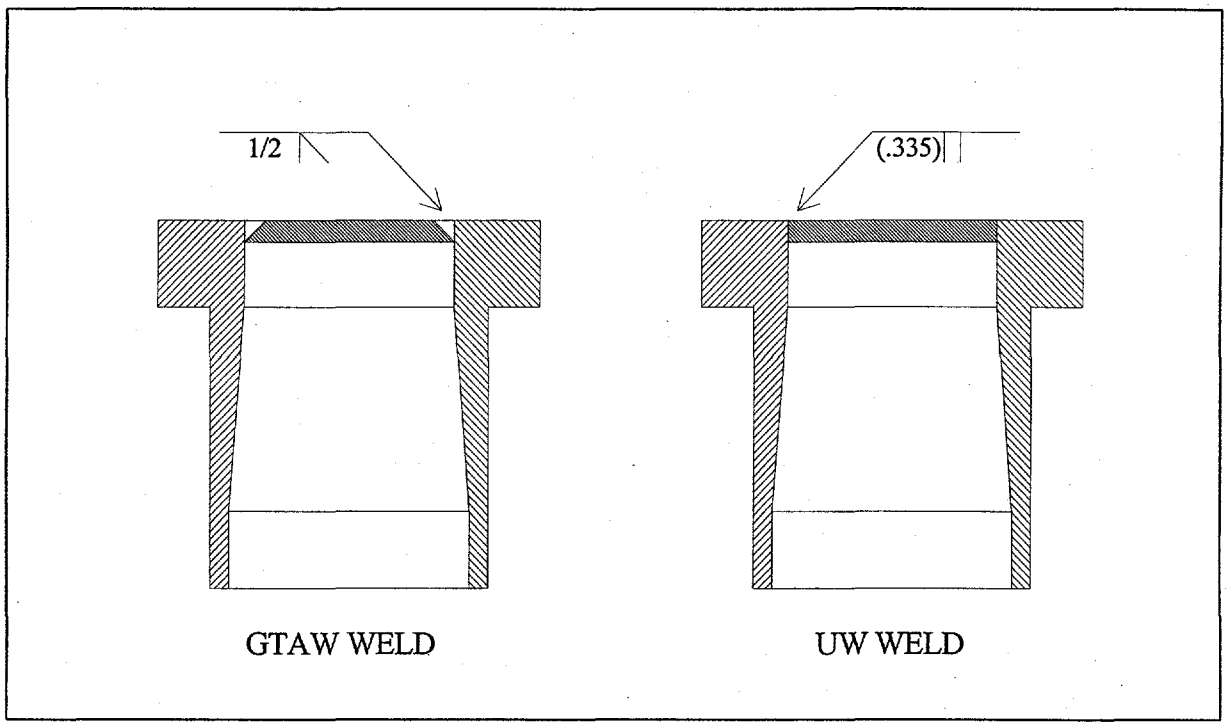

FIGURE 1 WELD JOINT DETAIL OF THE GTAW AND UW CLOSURES